



UNIVERSITI PUTRA MALAYSIA

**RISK ASSESSMENT OF KUALA LUMPUR MUNICIPAL
LANDFILLS-DELPHI APPROACH**

THENG LEE CHONG

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**RISK ASSESSMENT OF KUALA LUMPUR MUNICIPAL
LANDFILLS - DELPHI APPROACH**

By

THENG LEE CHONG

**Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of
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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

**RISK ASSESSMENT OF MUNICIPAL LANDFILL SITES IN
KUALA LUMPUR – THE DELPHI APPROACH**

By

THENG LEE CHONG

April 2000

Chairman: Associate Professor Dr. Mohd Nasir Hassan

Faculty: Science and Environmental Studies

Most of the solid waste disposal sites in Malaysia are either open dumps or controlled tipping. The risks from these sites are expected to be high especially the contamination of soil, air, surface and underground water, and also the impacts on flora and fauna. All these impacts have direct and indirect links to human being. The risks associated with solid waste disposal sites involved three compartments or media, i.e. the atmosphere, water and soil. This 'Cross media' or 'Multimedia' impacts phenomenon has made risk assessment of landfill site as a complicated process. This study discusses the development of a simple risk assessment systems for landfill sites by using the Delphi Approach, which emphasises the development of weightage for different parameters selected in the risk assessment procedures. The environmental conditions and risks of all closed and active disposal sites in Kuala Lumpur are assessed based on nine criteria representing the multi-media components of the environment, i.e. water quality, social, gas emissions, landuse, hydrology, geology, ecotoxicology, plant ecology and chemical constituents in soil and groundwater. These criteria have gathered 59 parameters and each parameter was assigned a

weightage of importance which was then assessed with the actual situation of the landfill sites. The final scores can be aggregated according to individual criteria or across the multi-criteria for the overall environmental conditions. The results of assessments indicated that most of the solid waste disposal sites in the study area showed significant level of risks especially the still active site, i.e. Taman Beringin landfill site. This study also presents the evaluations of the pollution levels of all the disposal sites in terms of water and soil contamination by selected chemicals, and also air pollution by selected gases emitted from the sites. Landfill Pollution Index (LPI) was also developed in this study and were calculated for each disposal site in the study area. The results show that Taman Beringin was the most polluted landfill with the LPI of 719.5576, followed by Jinjang Utara (383.5085), Paka 1 (197.6589), Brickfields (128.8949), Paka 2 (113.7235), Sri Petaling (30.8083) and Sungei Besi (17.8656). In summary, new evaluation systems had been introduced in this study in order to produce simple and reliable tools to evaluate or assess the pollution and risk levels for municipal waste landfill sites in Malaysia. Based on the assessment of Kuala Lumpur landfill sites, it can be concluded that the risk and pollution levels of landfill sites in Kuala Lumpur area are relatively high, but it is site-specific and various from one landfill site to another.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**PENILAIAN RISIKO TAPAK PELUPUSAN SISA DI KUALA LUMPUR –
KAEDAH DELPHI**

Oleh

THENG LEE CHONG

April 2000

Chairman: Profesor Madya Dr. Mohd Nasir Hassan

Faculty: Sains dan Pengajian Alam Sekitar

Kebanyakan tapak pelupusan sisa pepejal di Malaysia adalah samada pembuangan terbuka atau pembuangan terkawal. Risiko yang timbul daripada operasi tapak-tapak pelupusan ini adalah dijangkakan tinggi dari segi pencemaran tanah, udara, air permukaan, air bawah tanah dan juga impak terhadap flora dan fauna. Kesemua impak ini mempunyai hubungan secara langsung dan tidak langsung dengan kesejahteraan hidup manusia. Risiko yang berkaitan dengan tapak pelupusan sisa pepejal melibatkan medium alam sekitar, iaitu atmosfera, air dan tanah. Impak bersilang atau “Cross Media Impacts” ini telah menjadikan penilaian risiko di tapak pelupusan sisa pepejal satu proses yang sukar dan kompleks. Kajian ini membincangkan pembentukan satu sistem penilaian risiko bagi tapak pelupusan sisa pepejal yang mudah dengan menggunakan kaedah Delphi yang menitikberatkan penggunaan pemberat atau “weightage” bagi setiap parameter yang terpilih dalam proses penilaian risiko. Keadaan alam sekitar dan risiko bagi semua tapak pelupusan yang tertutup dan aktif di Kuala Lumpur telah dinilai berdasarkan sembilan bidang berlainan yang mewakili impak bersilang bagi komponen alam sekitar iaitu kualiti air, sosial, pelepasan gas,

penggunaan tanah, hidrologi, geologi, ekotosikologi, ekologi tumbuhan dan analisis bahan kimia di dalam tanah dan air bawah tanah. Kesemua bidang ini melibatkan 59 parameter berlainan dan setiap parameter diberikan satu pemberat mengikut kepentingannya yang kemudian digunakan untuk menilai keadaan sebenar di setiap tapak pelupusan. Jumlah skor akhir boleh dikira mengikut bidang secara individu atau mengambilkira kesemua bidang sekali untuk keadaan alam sekitar secara keseluruhan. Keputusan kajian menunjukkan bahawa kebanyakan tapak pelupusan sisa pepejal di Kuala Lumpur menunjukkan paras risiko yang ketara terutamanya tapak yang masih aktif, iaitu Tapak Pelupusan Taman Beringin. Kajian ini juga menunjukkan penilaian terhadap tahap pencemaran kesemua tapak pelupusan yang berkenaan dari segi pencemaran air dan air bawah tanah, pencemaran tanah oleh bahan-bahan kimia dan juga pencemaran udara akibat pelepasan gas dari tapak pelupusan. Satu Index Pencemaran Tapak Pelupusan Sisa (LPI) juga telah dibentuk dan dikira untuk setiap tapak pelupusan di dalam kawasan kajian. Keputusan menunjukkan bahawa Taman Beringin juga merupakan tapak yang paling tinggi tahap pencemarannya dengan LPI sebanyak 719.5576, diikuti oleh Jinjang Utara (383.5085), Paka 1 (197.6589), Brickfields (128.8949), Paka 2 (113.7235), Sri Petaling (30.8083) dan Sungei Besi (17.8656). Sebagai ringkasan, sistem penilaian yang baru telah diadakan dalam kajian ini untuk memberikan satu kaedah yang mudah dan boleh dipercayai dalam menilai tahap pencemaran dan risiko tapak pelupusan sisa di Malaysia. Berdasarkan keputusan penilaian yang diadakan di Kuala Lumpur, dapat disimpulkan bahawa tahap risiko dan pencemaran tapak pelupusan di Kuala Lumpur adalah tinggi, tetapi ia adalah berbeza antara satu sama lain.

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I certify that an Examination Committee met on 22nd April 2000 to conduct the final examination of Theng Lee Chong on his Master of Science thesis entitled " Risk Assessment of Kuala Lumpur Municipal Landfills - Delphi Approach" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

WAN NOR AZMIN SULAIMAN, Ph.D.
Faculty of Science and Environmental Studies
Universiti Putra Malaysia
(Chairman)

MOHD NASIR HASSAN, Ph.D.
Associate Professor,
Faculty of Science and Environmental Studies
Universiti Putra Malaysia
(Member)

MUHAMAD AWANG, Ph.D.
Professor,
Faculty of Science and Environmental Studies
Universiti Putra Malaysia
(Member)

MD. YAZID MOHD SAMAN, Ph.D.
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Member)



MOHD GHAZALI MOHAYIDIN, Ph.D.
Professor/Deputy Dean of Graduate School,
Universiti Putra Malaysia

Date: **27 APR 2000**

This thesis submitted to the Senate of Universiti Putra Malaysia and was accepted as fulfilment of the requirements for the degree of Master of Sains.

KAMIS AWANG, Ph.D,
Associate Professor
Dean of Graduate School
Universiti Putra Malaysia

Date: 8 JUN 2000

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



THENG LEE CHONG

Date: 27th April 2000

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Risk is an unavoidable feature of human existence. Neither man nor the organisations and societies to which he belongs can survive for very long without taking risk (*Ansell and Wharton, 1992*).

Risk assessment has been used in formulating the environmental policy of a country. However, the initial efforts relied more on intuition than on the scientific principles of toxicology, chemistry and fate and transport modelling which are used in modern risk assessment studies. It was only in recent years that the approach of scientific-based risk assessment played a major role in environmental decision making (*Maughan, 1993*).

In the case of solid waste landfill sites, information and knowledge on the risk and pollution levels are useful to decision makers as to the consequences of any possible actions to be taken. Some important decisions that could use or rely on the risk estimates include selecting waste treatment or disposal options, remediating contaminated sites, minimising waste generation and siting new facilities (*Tchobanoglous et al. 1993*). However, it should be emphasised that risk assessments or risk estimates are only one of many information used, and the final decisions are usually driven by political, social and economic factors.

There are many methods to treat and dispose of solid wastes. In most of the developing countries including Malaysia, landfilling is the most widely used methods for the disposal of solid wastes. Landfill is the oldest method, it has a wide range of capabilities and in most instances, it is the least expensive method. Landfill can take all types of non hazardous wastes and the environmental impacts are relatively lower than other disposal systems especially incineration (*Tchobanoglous et al. 1993*).

Most of the closed and existing landfill sites in Malaysia are either open dumps or controlled tipping (*Lee and Sivapalasundram, 1979*). The technology of proper sanitary landfill system is not totally implemented. The risks from these sites are expected to be significant especially in terms of the soil, air, surface and underground water pollution, and also the impacts of these pollution on flora and fauna including the general safety of the public due to landfill settlement and exposure to the pollutants.

Today, the major problem faced by landfill sites is acute shortage of land and land prices are becoming more expensive. Thus, closed landfill sites are given serious attention for development purposes. In this case, detailed studies on the risk of the landfill sites conditions are necessary before the proposed developments are to be carried out. Various aspects of the landfill sites that need to be assessed include hydrological and geological characteristics, water quality and gas emissions, the impacts of pollution on fauna, flora and also human health. Based on the combination of all these information, the risk and pollution levels of the landfill sites can be

assessed and decisions can be made to select the appropriate rehabilitation and remedial alternatives of the sites for future development.

1.2 Objectives of the Study

The main objective of the study is to develop simple method of risk characterisation and assessment systems for closed and active landfill sites in order to investigate and assess objectively the environmental conditions, pollution and risk levels of selected municipal landfill sites in Kuala Lumpur. Since the environmental impacts of landfill sites involve various environmental compartments which are known as "Cross-media impacts" or "Multimedia impacts", the Delphi method is used in the study. The multi factors considered in this method include hydrology, landuse, geology and geotechnics, social aspects, water quality, gas emissions, flora and fauna studies and also levels of chemical contamination in soil and groundwater. The end result is the development of a system that is able to assess the level of risk at landfill site from various perspectives, i.e. in terms of pollution levels, individual criteria and the overall risk.

The specific objectives of the proposed study are as follows :

- a) To identify the parameters in characterising and assessing of the environmental conditions, risk and pollution levels of a landfill.
- b) To develop representative weightage and ranking of each parameter according to their importance in characterising the risk levels using the Delphi approach.

- c) To develop a simple method of risk characterisation and quantitative assessment based on predetermined pollution and risk levels and subsequently to develop and calculate the Landfill Pollution Index (LPI) for all landfill sites in the study area.
- d) To systematically computerise the Landfill Pollution Index (LPI) evaluation system with more accessible and user friendly manner.

1.3 Significance of the Study

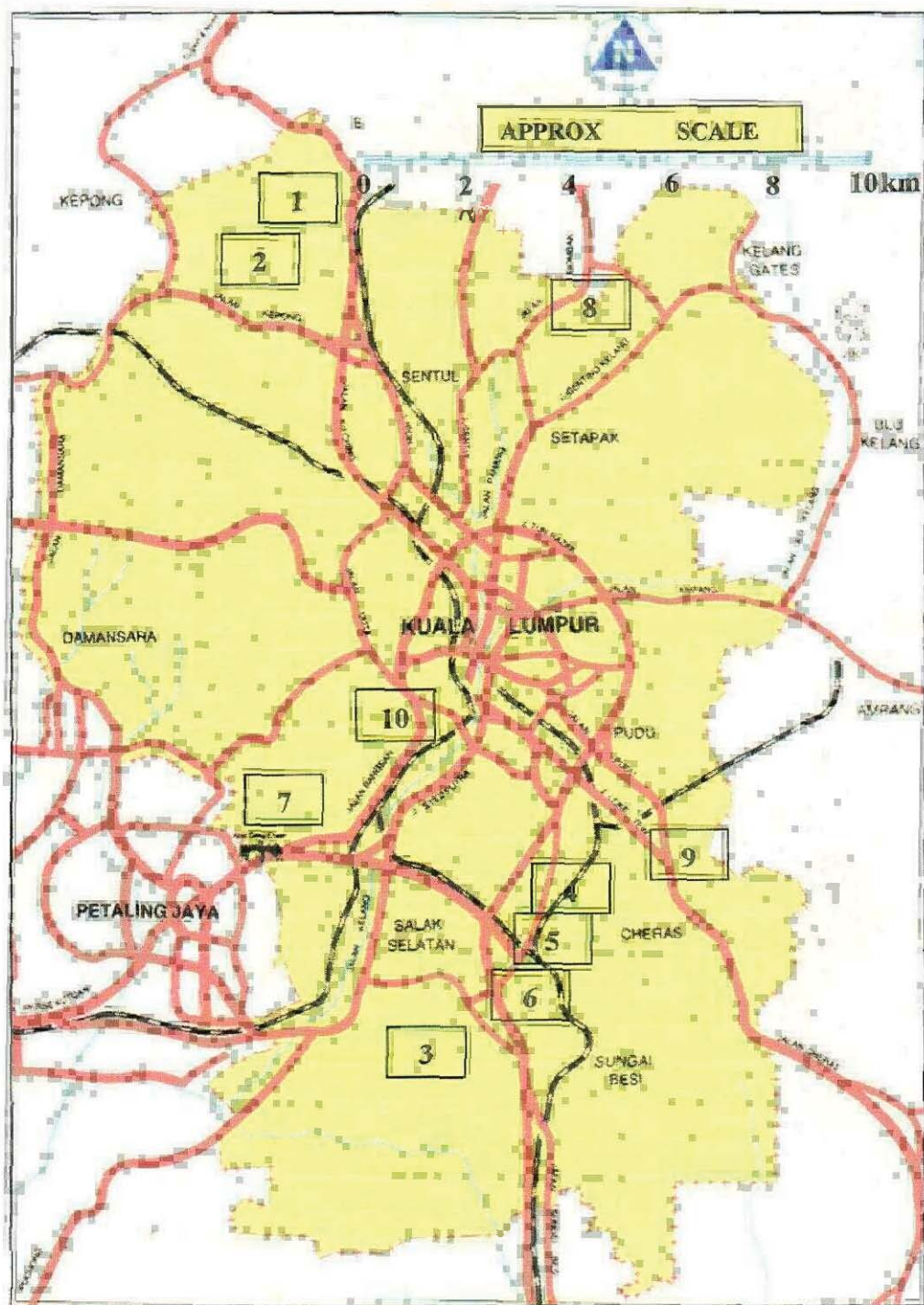
The study developed a simple method of quantitative risk characterisation and assessment system and eventually the landfill Pollution Index (LPI) for municipal landfill sites in Kuala Lumpur based on the Delphi approach. This approach would complement single criteria such as cost-benefit analysis (*Wilson, 1982*) or other multi-criteria methods such as Environmental Impact Assessment (*Turner and O’Riordan, 1982*) or Geographical Information System (GIS). The problem with other multi-criteria methods is that the results could not be added into a single score. As a result, it is difficult to compare the performance of one project to another. The strength of Delphi Approach is that it allows the evaluation of many parameters from different criteria and units by putting all these parameters into a single scale. The system developed by using Delphi Approach could be applied to other landfill sites. The systems would enable decision makers to understand the conditions or status of both the closed and active landfill sites. Besides, the conditions of landfill sites would also be more accessible and meaningful to the landfill operators and the general publics in terms of

its environmental impacts. The present study would also be useful in providing information especially to the landfill operators and decision makers as database in the formulation and execution of a cost-effective and efficient remediation or reclamation plan, as well as other systematic solid waste disposal programmes.

1.4 Study Area

The study area is located in the Federal Territory of Kuala Lumpur. Kuala Lumpur has the total area of 234 km² and it is characterised by highly populated, urbanised, and the most industrialised area in the country. As the centre of administration, industrialisation, commerce, finance and culture, Kuala Lumpur is experiencing rapid population growth. By assuming the population average growth rate of 2.5 percent, the area is expected to have about 3 million people by the year 2020 and the waste generated is expected to increase to about 5,000 tonnes per year (*Nasir et al. 1995; Nasir et al. 1996*).

The rapid population growth and development experienced by this urban centre has created major environmental problems and issues. One of the major problems is the increased in the amount of solid wastes generated. The solid wastes are mainly derived from various locations or areas such as the residential, commercial, institutional, industrial and construction areas.



Sites: 1-Taman Beringin, 2-Jinjang Utara, 3-Sri Petaling, 4-Sungai Besi, 5-Kg. Paka 2, 6-Kg. Paka 1, 7-Abdullah Hukum, 8-Air Panas, 9-DBKL, 10-Brickfields.

Figure 1.6 Landfill Sites in the Federal Territory of Kuala Lumpur

There are ten (10) dumping sites used to receive solid wastes in the study area and out of these, seven (7) were selected for the study, i.e. Sri Petaling, Brickfields, Taman Beringin, Jinjang Utara, Sungei Besi, Paka 1 and Paka 2 (See Figure 1.1). Taman Beringin is the only site which is still receiving wastes or still in operation during the study period, while the rest of the sites have been closed. General information of all the selected landfill sites are showed in Table 1.1

Table 1.1 General Information of Selected Landfill Sites in the Federal Territory of Kuala Lumpur

Landfill Site	Location	Year Started	Year Closed	Area (acres)	Amount (tonnes)		Distance from Kuala Lumpur Town Centre (km)
					Total Wastes Deposited	Tonnes / day	
Sri Petaling	03°03.50'N, 101°41.73'E	1979	1991	52	7.1	1,500	15
Sungei Besi	03°06.53'N, 101°42.56'E	1989	1995	34	3.1	1,200	10
Paka 2	03°06.02'N, 101°42.04'E	1989	1994	25	3.3	1,500	10
Paka 1	03°12.80'N, 101°41.81'E	1989	1994	32.2	3.1	1,400	10
Taman Beringin	03°13.78'N, 101°39.72'N	1991	Operating	30	5.8	2,000	3
Jinjang Utara	03°12.80'N, 101°39.72'E	1979	1996	162	6.6	1,000	20
Brickfields	03°07.80'N, 101°41.00'E	N.A.	N.A.	7	0.5	1,000	2

Note : N.A. = not Available